NHMA

Natural Hazard Mitigation Association

Natural Hazard Mitigation Association (NHMA) White Paper: FEMA's Benefit Cost Analysis (BCA) and Recommendations to Enhance its Mitigation Grant Process

March 15, 2021

Executive Summary

The Natural Hazard Mitigation Association (NHMA) is a non-profit organization dedicated to reducing the impacts of natural hazards that become disasters and enhancing safe and sustainable infrastructure and community resilience. Members of the NHMA Disaster Risk Reduction Work Group developed and wrote this paper to highlight some of the main issues with FEMA's Benefit-Cost Analysis (BCA) and propose solutions to these issues. Although other reports have discussed issues with FEMA's BCA, we hope that this paper will provide a comprehensive overview of the BCA's main issues and their possible solutions.

State and local officials from nearly every FEMA Region were interviewed and consulted for their experiences or sent the paper for review; common themes emerged from there. The BCA's software and policy issues negatively affect hazard mitigation funding processes. The inputs and data collection method required by FEMA strains subapplicant resources excessively, causing subapplicants to seek external expert assistance.

The BCA also does not encourage comprehensive mitigation solutions, which seems to contradict the intent of FEMA's vision and goals. Most significantly, the BCA prevents or deters subapplicants from pursuing mitigation projects, particularly if the subapplicants lack the resources (monetary or expertise) or are located in rural areas. FEMA cannot resolve these equity issues until the BCA is reformed.

We propose six recommended actions to make the BCA program more usable, organized into three shorter-term solutions and three longer-term solutions based on their expected timeframes for implementation.

In the shorter term, FEMA should:

1. Offer more software training and technical assistance to users.
2. Increase maximum funding for project scoping.
3. Allow applicants and subapplicants to use other federally approved BCA tools such as USACE's BCA to complete grant applications.

To improve the BCA Program, in the long run, FEMA should:

1. Fix the BCA software.
2. Alter FEMA policy on data inputs and backup documents.
3. Create a review program to accept additional FEMA-approved BCAs.

To achieve these solutions, FEMA should conduct internal reviews of these issues, establish working groups of users, policymakers, and experts to address these issues, identify the resources needed to resolve these problems, and allocate the resources to do so.

We appreciate FEMA's vision to continue to encourage communities to form new partnerships, develop innovative approaches, and consider threats more holistically. However, we are concerned that the current BCA will continue to hinder FEMA's hazard mitigation funding process. At the very least, we hope to begin a formal dialogue with FEMA about reforming the BCA, similar to the dialogue that led to the 2008 BCA conference.

Natural Hazard Mitigation Association (NHMA) White Paper[1]:
FEMA's Benefit Cost Analysis (BCA) and Recommendations to Enhance its Mitigation Grant Process

March 2021

Table of Contents

[1] The Natural Hazard Mitigation Association (NHMA) is a non-profit volunteer organization dedicated to reducing the impacts of natural hazards that become disasters and supporting safe and sustainable infrastructure and community resilience.

Introduction

This paper seeks to evaluate the Federal Emergency Management Agency's (FEMA) Benefit Cost Analysis (BCA) and its relationship to FEMA's mitigation grant application process. We are confident that the proposals in this white paper will resolve some of the main challenges associated with the BCA, which will improve FEMA's funding application process significantly. To this end, the objective of this paper aligns with goals 1.1 and 3.4 of FEMA's 2018-2022 Strategic Plan. Goal 1.1 calls FEMA to "[…] reduce disaster costs at all levels," and goal 3.4 calls FEMA to "strengthen grants management, increase transparency, and improve data analytics."[2] Our commentary is most relevant for pre-disaster funding programs, specifically the Building Resilient Infrastructure and Communities (BRIC) program. Nonetheless, many of the issues and themes outlined in this paper apply to other FEMA programs that use FEMA's BCA.

Our evaluation is divided into seven sections and relies on a combination of user testimony, relevant literature, and case studies.[3] This paper begins with a brief section on the BCA's overview and history, highlighting FEMA's historical use and reform of the BCA. The following section summarizes previous academic, public, and private studies of the BCA to emphasize the importance of this study, especially for BCA version 6.0. The third section discusses three main obstacles with the current BCA software. The fourth section outlines four policy issues with the BCA. The fifth section notes the effects of these problems on FEMA's consistency with federal directives and on its grant application process. The sixth section proposes five possible solutions to resolve the main challenges with the BCA. The final section recapitulates the key takeaways from this paper.

Overview and History

FEMA uses its BCA as one of many review mechanisms to determine how to allocate federal funds for mitigation projects. This paper separates the BCA into program and software elements to examine both independently. The BCA program refers to the administrative and technical resources needed to run and review the BCA. This includes staff assigned to maintenance, outreach, development, and troubleshooting, among other related tasks. The BCA can also refer to a software tool, which is currently developed by FEMA through a private contractor. Despite this paper's independent examination of the two elements, both elements depend on each other. Failure to solve the policy issues outlined in this paper probably will continue to make the BCA program and software ineffective and inadequate for many of its users.[4]

During the grant application process, grant applicants (states or territories) and subapplicants (jurisdictions within states or territories) upload and modify data on this software to determine a project's Benefit Cost Ratio (BCR). The BCR is calculated by weighing a project's costs and benefits. The BCR determines a project's eligibility; projects with a BCR equal to, or exceeding, 1 are eligible for award.

[2] FEMA, *2018-2022 Strategic Plan*, March 15, 2018, 12, 28.
[3] Testimonies drawn from interviews with BCA users in January 2021. Most of these users are located near Tulsa, Oklahoma or are associated with the NHMA. A list of contributors can be found in the appendix. Transcripts of these conversations were not recorded, but notes can be provided upon request. Other experts also provided their time and opinions, however, the views expressed in this paper represent the views of the signatories only.
[4] This relationship will be outlined more clearly in the policy section below.

The BCA's chief legal basis is derived from the amended Stafford Act (sections 404 and 406), although the historical roots for this type of federal benefit-cost analysis can be traced to at least the early 20th century.[5] Title 44 Code of Federal Regulations and the OMB Circular A-94 (revised) delineate the parameters for FEMA's BCA.

FEMA began developing its current BCA program in the early 1990s. FEMA has changed its BCA program several times, perhaps most significantly in 2008, when it worked with applicants and subapplicants to redesign its BCA software.[6] In 2019, FEMA released BCA version 6.0 to the public, which remains the current version as of this writing. FEMA requires projects to use the current version of the BCA (version 6.0) in their grant application process.

Previous Studies

Questions about BCA's usability have captured the attention of only a few formal studies in recent years, with most of these studies originating from the private sector. To our knowledge, no formal study addresses the usability of the current BCA (version 6.0) by privileging local sources from across the country, which makes this paper an important piece of the discussion to change the BCA.

Until recently, there were few public studies that addressed the usability of BCA version 6.0. FEMA produced several technical reviews that analyze aspects of past BCA versions.[7] FEMA also distributed guiding reports and documents to assist users with troubleshooting and to provide a comprehensive overview of the software's offerings.[8] The most prominent publicly available commentary from a federal agency was released by the U.S. Government Accountability Office (GAO) in early 2021. It should be noted that this report makes no specific mention of BCA version 6.0 but instead addresses the BCA in general. Themes from this report, titled "Disaster Resilience: FEMA Should Take Additional Steps to Streamline Hazard Mitigation Grants and Assess Program Effects," overlaps with many of the BCA testimonies we received during our research. The BCA recommendations from this GAO report were that FEMA needed to develop more pre-calculated benefits and should provide the methodology reports for those pre-calculated benefits among others. This convergence with GAO's research suggests that the sentiments expressed in this paper apply to more commentators than to the people interviewed in this paper. References to "GAO report" in the rest of this paper refer to this specific report. FEMA also released the "Summary of Stakeholder Feedback: Build Resilient

[5] Maynard M. Hufschmidt, "Benefit-cost analysis: 1933-1985," *Journal of Contemporary Water Research and Education* 116, no. 1 (2000): 42.
[6] FEMA, *Final BCA Reference Guide*, (2009), 1-1.
[7] An example review of BCA 4.5 can be found in: FEMA, "FEMA Benefit-Cost Analysis Re-engineering (BCAR): Damage-Frequency Assessment (DFA) (Limited Data Module/Unknown Frequency Determination)," *Methodology* Report (2009): 1-44.
[8] See sections of *The Benefit Cost Reference Guide* and *Supplement to the Benefit Cost Reference Guide*, which are considered the primary BCA guidance documents. These sections include general costs, values, and displacements, among other factors. FEMA, *Final BCA Reference Guide*, (2009), appendices A-C; FEMA, *Supplement to the BCA Reference Guide*, (2011), sections 2-5.

Infrastructure and Communities (BRIC)," which contains feedback that overlaps with testimonies in our paper.[9]

Academic reviews of FEMA's BCA are limited, with most scholars choosing to analyze the economic and theoretical underpinnings of the BCA within the federal regulatory framework rather than the functionality of the BCA software. Most academic scholarship does not include any commentary on the usability of FEMA's BCA analysis.[10] Several studies address these aspects of the BCA tangentially. Mehdi Noori et al. conducted one of the most prominent academic studies related to the BCA's usability. In their quantification of break-even mitigation percent, they express some concerns about the BCA's shortfalls, including its limited section of structures and its relative inability to compare fragility curves.[11]

Of these three camps, the private sector has addressed FEMA's BCA the most consistently, but many of these commentaries are limited to a specific hazard or regional application of the BCA rather than a holistic assessment of the software.[12] A 2016 study on Coastal Flooding Hazard Mitigation by ICF employees seems to provide the closest comprehensive analysis of FEMA's BCA in recent years. Their analysis highlights several factors that limit the usability of the BCA tool, namely, that its encoded data is rigid and outdated. These issues, compounded with the BCA's requirement for specific and individualized inputs for each structure, make large complex projects particularly difficult. Addressing these challenges, the study notes, "we would like to see the model be able to accommodate larger scale, macro-level analyses with greater flexibility as the tool continues to evolve."[13]

Few studies have commented formally on the problems with current BCA, version 6.0, as of this writing. Almost no studies from the private sector have linked testimonies from local and state commentators to public and academic reports. To this end, these testimonies from FEMA's BCA users (subapplicants) are extremely useful to meeting the critical gap in academic, public, and practical literature on the BCA.

Technical Issues

Most of the issues outlined in this section are issues with the software. This may bode well to resolve the issues outlined in the paper, since most of them relate to only the software and not to

[9] FEMA, "Summary of Stakeholder Feedback: Build Resilient Infrastructure and Communities (BRIC)," March 2020.

[10] See, for example: Susan E. Dudley; Brian F. Mannix, "Improving Regulatory Benefit-Cost Analysis," *Journal of Law & Politics 34*, no. 1 (Fall 2018): 12; Brian F. Mannix, "Benefit-Cost Analysis as a Check on Administrative Discretion," *Supreme Court Economic Review 24*, no. 1 (2017): 162; Keith Burbank, "An economist's role in disaster mitigation at FEMA," *Business Economics* 44, no. 3 (2009): 177-181.

[11] Mehdi Noori, Reed Miller, Randolph Kirchain, and Jeremy Gregory, "How much should be invested in hazard mitigation? Development of a streamlined hazard mitigation cost assessment framework," *International journal of disaster risk reduction*, 28 (2018): 578-584. This study reviewed BCA version 5.2.

[12] For some examples, see: John Eidinger, "Fragility of non-structural components for FEMA benefit cost analysis," *G&E Engineering Systems Inc., Olympic Valley, CA* (2009); Francis M. Lavelle, and Peter J. Vickery, "Interactions among Wind Mitigation Features in Benefit/Cost Analysis," In *Advances in Hurricane Engineering: Learning from Our Past*, eds. Christopher P. Jones and Lawrence G. Griffis, pp. 1067-1077. 2013.

[13] Will Cooper, Federico Garcia, Diana Pape, David Ryder, and Ben Witherell, "Climate change adaptation case study: benefit-cost analysis of coastal flooding hazard mitigation," *Journal of Ocean and Coastal Economics* 3, no. 2 (2016): 3.

the BCA program. That being said, previous studies and user testimony have outlined similar issues on previous BCA versions. The BCA program has continued to release software with these recurring issues, despite public appeals to resolve them, which suggests that these issues continually miss the attention of BCA administrators. The following section on policy issues addresses the main issues with the BCA program more directly.

This list of concerns is not exhaustive. Instead, it provides an overview of some of the main issues with the current BCA software and its administration. We have identified three considerations we would like FEMA to consider.

1. Inability to import data spreadsheets

BCA 6.0 has an import option, but it is limited at best. The current iteration allows users to upload basic data columns such as addresses. Still, it does not allow users to import other important columns, including flow rates and elevations (on flood projects, for instance). Users must paste hundreds of data points or enter them manually, which can lead to human-induced errors and significantly increased project times. This includes inputting data entry for each alternative as well. Transaction limits in version 6.0 cause the entire BCA to crash, and the user must re-enter all data. This is incredibly burdensome to the subapplicant, especially on projects with several hundred benefiting structures. FEMA has acknowledged this issue and is working to address it with a batch import function in the BCA Toolkit 6.0 set to release later this year.

2. Unreliability of data

The BCA's data unreliability is driven by inconsistent BCR tabulations, unclear calculations, and other possible software issues.

A) The BCA can produce extremely unreliable BCR tabulations, which seem relatively or completely unrelated to the data entered

This is especially the case for large projects with hundreds of data points, implying that the software is unable to manage large datasets. We provide a few examples to illustrate the breadth and scope of this unreliability:

- A user can add the same data and get a different BCR, holding everything else equal.
- A user who clicks through all of the BCA's menus gets a different BCR than a user who exits the program, holding everything else equal.
- Actions that clearly add benefit per FEMA guidelines, like raising structures above base-flood elevations, can register no benefit or even a negative benefit.
- Building from the previous point, tabulated values themselves vary extremely widely, from negative benefits, to zero, to infinity.

B) The software's inconsistent tabulations are compounded by a lack of clarity about how the tabulations are calculated

Although FEMA offers resources that provide some guidance on data entry, such as precalculated benefits, most tabulations in the BCA remain hidden from the user.[14] Some of FEMA's guiding documents provide information from previous BCA versions. These guides can

[14] For precalculated benefits, visit: https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis (accessed January 11, 2021).

be helpful, but they do not outline the exact tabulations in the BCA software, including version 6.0.[15] It should be noted that FEMA does make methodology reports available by request; however, these reports are highly technical and not easily understood. Further many BCA users are not aware of the availability of this provision.

The BCA software seems to have size restrictions that affect project results. There is no publicly available guidance on the quality or relevant details of these tabulations or restrictions. Correspondence with FEMA's BCA help desk and systems engineers from the current BCA software developer reveals how convoluted the BCA's software has become. Fielding a question regarding why the BCA software continued to crash randomly, a systems engineer reported that:

> there is a limit to the number of projects that can be entered. The limit is variable depending on the type of mitigations actions created and comments making up the project. For the time being, can you separate out your projects in half between two, separate template files (you can export out one half) [sic].[16]

This response reveals several flaws in the BCA program (the administration of the BCA) and the BCA software (the technical components making up the software itself):

- The existence of a project size limit in the software, which FEMA or its private developer did not clearly communicate to users (BCA program).
- FEMA's BCA help desk forwards large, technical questions to its private developer suggesting that technical communication and assistance between the two entities could improve (BCA program).
- The software's limit varies depending on several undisclosed factors, which may have led the engineer to provide troubleshooting advice rather than a concrete list of actions (BCA software).

Following the engineer's guidance, BCA users noted that halving a large project still crashed the software data as frequently as before. Although this correspondence refers to a single large-scale BCA project, it was included because it illustrates several key problems with the BCA program and the BCA software.

3. Other features causing crashes or other factors contributing to the software's unreliability

It is possible that the software's unreliability results from the two issues listed above, but testimonies from BCA users suggest that this is not the case. Most BCA testimonies suggest a positive correlation between the complexity of a project and the likelihood of crashes in the software. Complexity in this case includes not only the number of structures and alternatives, but also the type of mitigation project (see the following section for more information). Some

[15] See sections of *The Benefit Cost Reference Guide* and *Supplement to the Benefit Cost Reference Guide*, which are considered some of the primary BCA guidance documents. These sections include general costs, values, and displacements, among other factors. FEMA, *Final BCA Reference Guide*, (2009), appendices A-C; FEMA, *Supplement to the BCA Reference Guide,* (2011), sections 2-5.

[16] Email provided to subapplicant, Region VI. Joe Johnson, a consultant at GOHSEP, suggested something similar in a workshop presentation, with his statement that "the BCA Helpline is FEMA's, but sometimes they don't even agree with it and need a third party to make a decision, but they will respond to inquiries." From, Joe Johnson, "Benefit Cost Analysis," University of New Orleans. *Disaster Resistant University Workshop: Linking Mitigation and Resilience* (2013) 3-2013.

commentators also suggested that the BCA occasionally would not report an error to users, even when an input resulted in an error. According to their testimony, a FEMA employee confirmed their observations.[17] FEMA commented on this issue stating that there was an intentional decision not to program in too many business rules to avoid added complexity for users. Instead, the intention was for FEMA reviewer(s) to flag input combinations that could result in errors. Following this comment, FEMA also stated that they agree that more business rules may need to be input into the software and that acceptable ranges for some inputs should be better communicated to users.

We have included a short list that outlines some common BCA unreliability issues:

- Almost any action (simple cost update, data entry, scrolling through the data) can cause the software to freeze completely.
- Almost any action can reset the entire software system, forcing the user to begin a project again.

In attempt to address these issues and to make the appropriate modifications to the software and/or Help Content and guidance, FEMA released an autorecovery feature in the BCA Toolkit that allows users who experience a crash or data loss to recover the most recently saved version of the file on April 26, 2021.

Policy Issues

This section discusses how the policy issues impact the BCA's usability. By policy issues, we mean decisions made by the BCA program on what parameters (inputs, backup documentation, etc.) will be acceptable for the BCA. We anticipate that this section, even more than the previous section, will highlight the interconnectivity between the BCA software and the BCA program.

This section separates policy issues into four categories: precision of input data, volume of input data, range of acceptable data, and technical support.[18] During our research and writing, a common theme emerged across all these categories. That is: the inputs and the method of data collection required by FEMA strains subapplicant resources excessively, causing subapplicants to seek external expert assistance. We discuss effects of this situation in the following section.

Language in FEMA's most recent Hazard Mitigation Assistance Guidance acknowledges that subapplicants use experts to collect and calibrate inputs for the BCA.[19] Nonetheless, FEMA may be unaware that subapplicants often *need* experts to meet BCA standards. This observation seems to hold true nationwide. One local emergency manager on the west coast noted that every subapplicant in their region completed a BCA with expert assistance.[20] This sentiment was

[17] Testimony from subapplicant in Region IV.
[18] Data volume and precision are discussed in this section instead of the technical issues section, since these elements have to do with FEMA's designated inputs for the software rather than a malfunction with the software. FEMA's data requirements are costly due to the precision and the amount of data required to run an acceptable BCA. This is particularly the case for projects that are large and complex, which places significant burden on applicants and subapplicants.
[19] FEMA, *Hazard Mitigation Assistance Guidance* (2015), 68.
[20] Testimony from subapplicant in Region X.

shared by state employees working in different regions. The GAO report observed a similar trend.[21]

1. The precision requirements for some inputs can strain subapplicant and applicant resources

A) FEMA's demand for precision often drives subapplicants to hire external consultants which causes lower income communities, who do not have the resources available to hire external help, to fall behind in Hazard Mitigation efforts

FEMA's precision standards for certain datasets often exceed a subapplicants abilities. Data services commonly collected and analyzed by external consultants include engineering surveys, such as a hydrology and hydrologic studies, seismicity analyses, land surveys, and other damage assessments. This seems particularly true for projects that mitigate against floods, landslides, earthquakes, or other hazards with a hydrological or geological component.

Theoretically, state employees could provide some of the expert assistance required to run the BCA properly. In reality, however, the trainings and the hours needed to meet the demands of BCA inputs almost always exceed the state's resources. State employees are inundated with other aspects of FEMA's funding process, such as reviewing subapplicant proposals and coordinating with their FEMA region, among other mitigation tasks. These employees often face high workloads, work in smaller teams, and are supported by small state budgets, which makes devoting additional time to subapplicants' BCAs secondary to implausible. One state employee noted that their office did not have enough time or resources to assist subapplicants with their BCAs, despite a clearly demonstrable need. His observation is congruent to the data collected by GAO, which notes that "officials from all 12 state and local jurisdictions we met with said that the benefit-cost analysis for hazard mitigations was a challenge due, in part, to the volume of resources and data needed."[22]

We understand that precision should be required for some inputs. Nonetheless, we are concerned about the burden it places on subapplicants. The lack of state resources to assist with BCA inputs often makes good private consultants "the only game in town." The cost of hiring private consultants who can meet BCA requirements can prohibit subapplicants from completing competitive projects, especially those in underserved communities. Several planners and emergency managers noted that the cost of meeting FEMA's precision stands made the risk too great to continue pursuing a project where the award money was not guaranteed. We address the effects of this concern on FEMA's grant application program more completely later in this paper.

B) The lack of a clearly defined precision standard for some inputs makes it more difficult for all contributors to render acceptable BCAs

Based on interviews and analysis, confusion over data precision is the case especially for BCA projects that address flood hazards. On several projects, FEMA rejected first-floor elevation data collected using Light Detection and Ranging (LiDAR) because the data conflicted with the topography of FEMA's own maps. As of this writing, LiDAR analyses have been well-accepted

[21] GAO-21-140, "Disaster Resilience: FEMA Should Take Additional Steps to Streamline Hazard Mitigation Grants and Assess Program Effects," (February 2021), 18.
[22] GAO-21-140, "Disaster Resilience: FEMA Should Take Additional Steps to Streamline Hazard Mitigation Grants and Assess Program Effects," February 2021, 18.

as meeting or exceeding precision standards for projects, including projects with a hydrological component.[23] Government agencies, such as NOAA, USGS, and NRCS, use LiDAR in their studies. In some cases, the LiDAR data that FEMA rejected came from a NRCS study.[24] Making these precision requirements doubly confusing is that FEMA guidance includes LiDAR as an acceptable tool to collect first-floor elevations.[25]

FEMA has a right to request further information about the precision of BCA inputs, which is vested in federal guiding documents and precedent. In reality, however, FEMA's request process has stalled projects and imposed additional costs on subapplicants. Occasionally, FEMA will request further clarification or reject a subapplicant's response even if that response seems to meet FEMA's comments. In some commentors' experience, these periods for comment and reanalysis can last for months, even years.[26] Completing re-evaluations also strains subapplicants' financial resources, especially for larger projects that require more complex engineering analysis. On one school retrofit project, a subapplicant had to pay approximately $30,000 to develop an additional seismicity analysis that would meet FEMA's precision comments.[27]

Unfortunately, insufficient data was collected to determine whether confusion over precision standards was a national issue or regional issue. Preliminary analyses suggest that this is a national issue. In regions where this is clearly an issue, FEMA seems to lack a defined mechanism to resolve data discrepancies from sources that it considers to be acceptable. Current practices suggest that FEMA defaults to its own data in these cases. In a hydrology example, this hypothesis suggests that FEMA will default to its two-foot contour FIRM maps over conflicting LiDAR data.[28] Although FEMA's strategy ensures that the data meets a minimum acceptable standard, FEMA risks precluding data collection methods that are more precise than its data. Irrespective of the approach that it chooses to resolve disputes over data precision, FEMA needs to make its approach explicit to subapplicants. Precision uncertainties also can increase the volume of backup documentation, which is discussed later in this section.

2. The volume of inputs and backup data required can strain subapplicant resources and prevent subapplicants from receiving benefits

A) The number of data inputs required to generate an acceptable BCA can cause applicants to rely on external assistance

The number of inputs required for small projects can be manageable, but larger projects can require hundreds of datapoints, which presents a serious challenge for subapplicants trying to meet FEMA's BCA standards. The resources needed to input high volumes of data in the BCA

[23] For some examples of academic studies see: Hongxing Liu, and Lei Wang, "Mapping detention basins and deriving their spatial attributes from airborne LiDAR data for hydrological applications," *Hydrological Processes: An International Journal* 22, no. 13 (2008): 2358-2369; Shane Furze, Jae Ogilvie, and Paul A. Arp, "Fusing digital elevation models to improve hydrological interpretations," *Journal of Geographic Information System* 9, no. 5 (2017): 558-575.
[24] Examples can be provided on request.
[25] FEMA, *Supplement to the BCA Reference Guide,* (2011), 2-47.
[26] Testimony from subapplicant, Region IV; Testimony from subapplicant, Region VI.
[27] Testimony from subapplicant, Region X.
[28] Testimony from subapplicant, Region IV.

properly, which is compounded by technical issues that often arise when managing these datasets, causes many subapplicants to hire external assistance.[29]

B) The volume and types of backup documentation also strain applicant resources and can lower BCRs

Most inputs to the BCA require backup documentation. The biggest strain on applicant resources often arises from uncertainty over which backup documentation can be considered acceptable. Several emergency managers, planners, and other local employees have noted that determining what documentation FEMA will accept can be a challenge, especially for benefits that are not as common. The GAO report noted a similar trend.[30] On several occasions, these commentators noted that they had to withdraw benefits from the BCA, lowering their overall BCR. Losing key points from benefits can change a project' eligibility, especially if the BCR is close to being eligible or ineligible.

3. FEMA's range of acceptable inputs provides less opportunity for less populated communities to add benefits

We find this concern most acutely for BRIC's BCA. In order to understand potential impact of population bias on project benefits, we outline how the BCR is calculated. As we argue, the level of benefits available to a subapplicant can determine whether a project is rendered acceptable according to FEMA's standards (BCR ≥ 1). If project benefits skew in favor of populated areas, we expect that the number of subapplicants submitting BCRs will bias populated areas, given the advantage that these benefits can provide.

A project's costs and benefits are weighted to determine its BCR. A BCA needs to render a BCR ≥ 1 to be considered cost effective and eligible for an award. According to FEMA's application of the BCA, the higher the BCR, the more cost-effective the project. Subapplicants can improve their BCR using two approaches: (1) by determining ways to lower costs or (2) by adding benefits.

There are few opportunities to lower costs for most projects because most costs are predetermined by the scope of the project. A project's scoping, design, and construction, for instance, generally are tied to market rates. Subapplicants may be able to lower costs somewhat using strategies like economies of scale or personal connections. Nonetheless, costs generally do not change significantly unless the scope of the project changes or market rates change. In fact, changes in market rates can make the BCA ineligible if costs rise and change the BCR to < 1 between the time when the project is awarded and when the project is funded. For this reason, most subapplicants do not feel comfortable submitting a BCR = 1; some incorporate a contingency that the BCR exceeds 1 significantly to increase the likelihood that the remains BCR ≥ 1.

A project's benefits are also tied to its scope, but FEMA allows these benefits to be somewhat more flexible, since subapplicants can "add" acceptable benefits to their BCR. The range of

[29] Testimony from applicant, Region III; Testimony from subapplicant, Region IV; Testimony from subapplicant, Region VI; Testimony from subapplicant, Region X.

[30] GAO-21-140, "Disaster Resilience: FEMA Should Take Additional Steps to Streamline Hazard Mitigation Grants and Assess Program Effects," February 2021, 21.

acceptable benefits, however, is skewed toward projects that impact more people. Many acceptable benefits are weighted based on population, with a higher population rendering a higher benefit number. Benefits like traffic counts, number of people serviced by a project element, and number of people located near a project favor more populated areas.[31]

This is the case especially for projects that can value "lives saved" into their analyses. BCAs that address hazards like tornadoes and hurricanes in highly populated areas typically render high BCRs.[32] Perhaps it is best to prioritize these projects given their emergency impacts, as the BCA currently does. Considering that this is a national competition, however, the BCA may skew towards pockets of the country that meet these criteria; coastal cities and urban areas in tornado alley, to name a few.

Conversely, population numbers in less populated areas may have impacted some of these projects from being submitted. By one local planner's testimony, one of their road projects should have been cost-effective on first glance, since the road overtopped annually. Yet, the subapplicant (a community) tabled the project, in part, because it could not find enough benefits to render an acceptable BCR. The planner expressed confidence that the project could have achieved an acceptable BCR had another housing development existed near to the road project.[33]

C) Precalculated benefits

In recent years, FEMA has included precalculated benefits for specific mitigation projects. Precalculated benefits have reduced the burden for some of the issues listed in this section. Nonetheless, precalculated benefits are limited for several reasons:

- They can only apply to a range of preselected projects. These projects tend to be smaller in scope.
- You cannot add additional benefits to precalculated benefits. This includes ecological benefits.[34]

Precalculated benefits may reduce strain on some applicants. Their limited application, however, indicates that precalculated benefits do not reduce strain on applicants in projects where it is most needed, namely: larger, innovative, and dynamic projects.

Per recommendations made by GAO, FEMA is currently developing new pre-calculated benefits to address a wider range of project types, including both infrastructure mitigation and nature-based solutions, which expects to release at least one per calendar year for the next several years.

4. There seem to be gaps in FEMA's technical assistance for the BCA

Gaps in technical assistance for the BCA were especially noticeable during BRIC's inaugural application cycle. According to applicants and subapplicants across several regions, FEMA did not offer any technical assistance on the BCA for BRIC, citing concerns that they would be

[31] According to expert testimony, the BCR for constructing hurricane shelters is contingent on the number of people that could conceivably reach the shelter prior to a hurricane's impact. The higher the concentration of people proximate to the project, the higher the BCR.
[32] Testimony from subapplicant, Region X; Testimony from subapplicant, Region VI.
[33] Testimony from subapplicant, Region IV.
[34] FEMA, "Ecosystem Service Benefits in Benefit-Cost Analysis for FEMA's Mitigation Programs Policy," *FEMA Policy FP-108-024-02,* September 28, 2020.

offering an unfair advantage to subapplicants who requested assistance.[35] We appreciate FEMA's desire for neutrality. Nonetheless, the Agency's decision seems to have inadvertently exacerbated some of the problems outlined in this section, as subapplicants had to rely on private contractors exclusively for assistance with their BCAs. In addition, FEMA's lack of technical assistance was compounded by a lack of readily available training courses on BCA version 6.0.

As of this writing, the BRIC program is in its first year of funding, leaving open the possibility that all contributors to the BCA process will become more efficient at managing the BCA. Indeed, the existence of assistance programs from some FEMA regions and some states suggests that this may be true. Nonetheless, subapplicants will continue to struggle until they can receive more technical assistance, which may have to come from FEMA.

Effects on FEMA's Funding Process

The software issues outlined in the previous section seem to disrupt three of the most important issues in FEMA's grant application chain. First, it does not clearly and transparently align the intent of guiding federal documents, especially OMB Circular A-94. Second, it conflicts with FEMA's recent move to advocate for system-wide, comprehensive mitigation solutions and instead privileges solutions that may not align completely with FEMA's current vision. Third, it can deter applicants from pursuing mitigation projects, particularly subapplicants with less technical experience and access to resources.

1. It is unclear to users that OMB A-94 is being followed and that users can request further information regarding transparency of the software

The lack of clarity and consistency in BCR software calculations conflicts with guiding sections in OMB Circular A-94. The "Explicit Assumptions" subsection of the Circular asserts that:

> Analyses should be explicit about the underlying assumptions used to arrive at estimates of future benefits and costs […] The analysis should include a statement of the assumptions, the rationale behind them, and a review of their strengths and weaknesses. Key data and results, such as year-by-year estimates of benefits and costs, should be reported to promote independent analysis and review.[36]

FEMA has released BCA guidelines and other documents that meet some of the criteria outlined above. The BCA software's BCR calculations conflict completely with the intent of this directive, however. In particular, analyses within the software are not explicit, which does not (cannot) "promote independent analysis and review" of FEMA's BCR. Because these equations involve complex calculus that is not widely understood, it is important that FEMA provides clarity on such calculations. FEMA has reported that they are working to update the BCA webpage and Toolkit Help Content to explain these calculations in a more basic way.

The BCR's unreliability also seems to not meet the replicability standard outlined in the "measuring benefits and costs" subsection, which states that "measures should be consistent with economic principles and should be replicable."[37] Although FEMA insists that users can request

[35] FEMA, "Region III State-requested Meeting," January 15, 2021.
[36] OMB Circular A-94, revised, 5.
[37] OMB Circular A-94, revised, 7. This statement applied to indirect measures of benefits and costs; we felt that it established a replicability standard for the entire BCA. FEMA precedent indicates as much.

methodology reports, few users know of this possibility. Further, because the equations used in the software are so highly technical, users could not understand the information even if it were given to them directly, defeating the purpose of transparency all together.

2. Disrupts solutions pursuant to FEMA's vision while privileging a narrow range of solutions

A) Disrupts comprehensive mitigation solutions

FEMA has encouraged grant applicants and subapplicants to pursue system-wide, comprehensive mitigation projects, especially in recent years. One of FEMA's new flagship mitigation programs, the BRIC Program, encourages subapplicants to add complexity to their projects through multiple partnerships, new funding mechanisms, and other innovative approaches to mitigation. BRIC also calls applicants to "offer multiple benefits to a community in addition to the benefit of risk reduction."[38] Programs like BRIC allow communities to develop holistic solutions that are better suited to protect people, the built environment, and the natural world. They also allow communities to align FEMA's five mission areas more closely, especially the mitigation and response areas, which increases overall community resilience.[39]

Although comprehensive solutions should be recognized as a helpful addition to FEMA's mitigation program, these solutions almost invariably add significant complexity to the BCA. Large projects correspond with increased complexity to the BCA in terms of the number of structures, key elements (such as elevations), and alternatives considered (what-if scenarios). A project at the scale of a neighborhood can include hundreds of structures and many alternatives, aggregating to thousands of datapoints.[40]

FEMA staff have indicated that users have the option to do some calculations/tabulations outside the BCA Toolkit and then enter as few as one row of data into the software. For example, damages to 100 homes can be tabulated in a separate Excel spreadsheet and the total amount can be entered in the BCA Toolkit. As long as the tabulation spreadsheet and source(s) for the values are provided with the application, this is a valid (and commonly-seen) approach. FEMA does agree, however, that they could provide better guidance on how to do this.

The BCA software, by contrast, is most usable for simpler projects, which tend to be smaller projects with very few structures and alternatives. The BCA's unreliability often increases as the complexity increases, which inadvertently punishes applicants developing more complex projects. Although the BCA can be unreliable for any project (see the previous section), users report that it is most unreliable for large projects. This seems to translate to project type as well. Large, residential projects seem to be more unwieldy than single road projects that do not mitigate any residential structures. This may be driven by data size, as residential projects tend to have more data points. Until FEMA reveals more about the software, however, hypotheses about data size will remain unanswered.

---

[38] FEMA, "Building Resilient Infrastructure and Communities (BRIC)," *website* https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities (accessed January 21, 2021)

[39] FEMA's five mission areas, as outlined in the national preparedness goal, are: protection, prevention, mitigation, response, and recovery. FEMA, *National Preparedness Goal*, 2nd edition (September 2015), 1.

[40] Testimony from subapplicant, Region IV; Testimony from subapplicant, Region VI; Testimony from subapplicant, Region X.

B) May skew toward larger, urban, and simple infrastructure projects
This is especially the case with BRIC. We noted this issue previously in the paper, but we return to it here because we are concerned that the current construction of the BCA will favor urban population centers at the expense of other areas. When asked about which projects are the most successful with a FEMA BCA, one Local Emergency Manager asserted that the BCA worked best for utility projects located near many people.

Most local and state commentators highlighted the same three elements that make a BRIC project successful: larger infrastructure projects, their proximity to population centers, and the effect of a hazard on population centers or infrastructure.[41] Yet, the BCA's policy and software also seemed to accept simple projects more readily. Considered in tandem, these statements seem almost paradoxical in the BCA's incentive structure. On one hand, the BCA seems skewed in favor large projects that deliver benefits to many people that surround them. On the other hand, the BCA's construction does not encourage complexity, which is often characteristic of large projects. In reality, only a narrow range of projects truly benefit from the current BCA.

Unless FEMA takes additional steps to balance these incentives, we suspect that large, urban, and simple projects will be overrepresented in BRIC applications. Examining FEMA's BCA within the entire cycle of mitigation funding exacerbates its inadequacy to meet the demands of FEMA's mitigation vision and national goal.

In many ways, FEMA pre-disaster grant programs are moving communities across the country toward integrated solutions and additional partnerships that will strengthen their mitigation processes and enhance resiliency. The BCA, in its current form, cannot meet the demands of these programs. We suspect that this will only worsen in time as projects increase in complexity. On the very extreme end, the BCA has discouraged subapplicants from applying for grant funding altogether.

3. Deters applicants from pursuing mitigation projects
A) The resource strain can deter any community from submitting mitigation projects
The BCA has deterred applicants from pursuing some projects, especially complex projects, which contradicts the intention of FEMA's hazard mitigation funding programs. The BCA prevented one innovative project from reaching the submission stages during BRIC's inaugural funding cycle. This project proposed a microgrid solution for a critical facility located in a floodplain. Given the complexity of the project, the subapplicant could not conduct the BCA internally, nor could it secure the resources to complete the BCA externally. The project was not submitted. A canal project of similar complexity faced the same BCA hurdle, which it overcame only by securing external assistance. Other successfully submitted BRIC projects also relied on external assistance for the BCA, suggesting that the BCA has become too unwieldy for most subapplicants to handle internally, even those that have received mitigation funding routinely in the past. This is due, in large part, to software problems (listed in the section above) and the BCA's demand for professionally sourced data. The latter issue was not addressed in the

[41] An example where the demonstrated effects of hazard effects matter most is NFIP claims. According to some commentators, a subapplicant may have additional difficulty showing benefits if less NFIP claims have been reported that the probable number of structures affected. Testimony from applicant, Region III.

previous section, as BCA's demand for the most reliable and precise measurements is not considered a shortfall, provided that FEMA upholds these standards consistently. Obtaining these data are costly, however, and usually outside subapplicants' resources and scope.

The BCA is not the only deterrent for communities looking for hazard mitigation funding, but it does explain why many projects are not submitted. We anticipate that this problem will only increase, especially as the incentives for complex and innovative projects increase.

B) Penalizes subapplicants with less technical experience and access to resources, which tend to be smaller, poor communities

Our equity concern stems from the previous concern. It focuses on the subapplicants that are most likely to withdraw from the application process due to resource constraints. Large wealthy communities have withdrawn from the FEMA funding process for resource issues, but we note that the overwhelming majority of withdraws seem to be smaller and poorer communities, which tend to be underrepresented and underserved. The BCA is not the only aspect that causes a community to withdraw. Nonetheless, it often plays a major role in a community's decision to withdraw because of the strain it places on resources.

Larger, wealthier communities usually have more resources to devote to overcoming the BCA. The BCA can be costly for every project, but the costs to complete the first are notably high. At a minimum, a community who has not completed a FEMA BCA has to learn how to operate the BCA sufficiently or hire experts to do so, develop or maintain strong communication channels with their state and FEMA region to resolve issues, and develop or maintain channels to access required data inputs for the BCA. Larger communities, particularly those with access to experienced contractors or a long history of successful grant applications, are better able to utilize the BCA software. Often, they have access to additional data, experience obtaining approval for alternative calculations, or the expertise to devote to overcoming the BCA hurdle.[42] Unequal access to resources creates a cyclical pattern. Previously successful communities continue their success. Many communities that do not have the resources to develop a BCA strategy continue to avoid FEMA grants, especially BRIC.[43]

This access issue is more significant than application statistics indicate. Examining the breakdown of awards to determine successful and unsuccessful subapplicants is an important aspect of this problem. Nonetheless, this analysis overlooks the subapplicants who *didn't even submit an application* due to resource constraints. Some of these subapplicants recognized that their project was sufficiently compelling to win an award. Yet, their lack of access prevented them from participating in the competition altogether.[44]

This subsection is not about who wins awards, which may also involve contested issues of equity. It is about which subapplicants can even enter the game. Larger, wealthier subapplicants have a better opportunity to absorb the cost required to complete the BCA. This is to say nothing

[42] Alessandra Jerolleman, Challenges of Post-Disaster Recovery in Rural Areas" in *Louisiana's Response to Extreme Weather: A Coastal State's Adaptation Challenges and Successes*, ed. Shirley Laska (Springer Open, 2020, 285-310.

[43] Testimony from subapplicant, Region VI.

[44] Testimony from subapplicants, Regions IV; Testimony from subapplicant, Region VI; Testimony from subapplicant, Region X.

about the benefits that populated areas can receive on the BCA itself.[45] We are concerned that this equity issue will grow as the resource strain placed on the BCA grows, especially with the advent of larger projects under BRIC.

Recommended Actions

Based on the BCA software issues and their ramifications on FEMA's observance of federal guidance and its grant process, we suggest six solutions to make the BCA program more usable. These solutions are separate, but not mutually exclusive. In fact, we encourage FEMA to implement all six solutions, as each offers benefits that could enhance the BCA and, by association, FEMA's entire mitigation funding process. These sections are organized into three shorter-term solutions and three longer-term solutions based on their expected timeframes for implementation. In order to address these issues, FEMA should conduct internal reviews of these issues, establish working groups of users, experts, policymakers and experts to address these issues, identify the resources needed to resolve these problems and allocate the resources to do so.

Shorter-term solutions

1. Make software training and technical assistance more available and more comprehensive

Based on our evaluation of the BCA software, the efficiency gain might be minimal if software training is used as the only solution. Given the lack of publicly available information about the BCA's software, however, it is possible that some of the software issues could be surmounted through training. A recent study conducted by Gavin Smith and Olivia Vila reported that nearly 64% of State Hazard Mitigation Officers and other state employees "rarely" or "sometimes" were given opportunities for BCA training. This statistic is especially concerning considering that 67% of the forty-two respondents reported using FEMA funding to manage BCAs.[46] These statistics are supported by testimony from our commentators, who indicate that state applicants and local subapplicants would benefit from additional training.

FEMA provides access to classroom training materials on their website to allow for informal independent study of the material. Acknowledging that FEMA has made training materials available for users, it is important to address the insufficient content of these trainings. By nature, the BCA software is dependent on project type; for this reason, trainings should be expanded to address the common issues experienced while working on specific project types. The current training is sufficient regarding general implementation of the BCA but proves inadequate regarding the unwritten rules and tips needed for project-type issues. FEMA is currently working to update the BCA webpage to have more of this type of content, as well as example BCAs and documentation for various project types. One further recommendation includes working with practitioners who have used the tool before to address the potential issues that may occur throughout the process for specific project types to help standardize the BCA process and to aid in better technical assistance.

[45] See section on less-populated communities.

[46] Gavin Smith and Olivia Vila, "A National Evaluation of State and Territory Roles in Hazard Mitigation: Building Local Capacity to Implement FEMA Hazard Mitigation Assistance Grants," *Sustainability* 12, no. 23 (2020): 10013.

Given the current lack of applicant and subapplicant resources to meet the demands of the BCA, FEMA should also consider offering more robust technical services, especially for BRIC. This can augment any additional training provided to interested parties. Some commentators suggested adding an annual "grace period" prior to the Notice of Funding Opportunity to allow more assistance for projects.

2. Increase the maximum funding allocated for project scoping

Most subapplicants cannot afford external assistance on their BCAs. Those who cannot afford external assistance often cannot submit the project for FEMA approval, unless they can complete the BCA internally. Increasing the maximum funding available for project scoping, especially for subapplicants that demonstrate need, will enable more subapplicants to hire external help they require to complete their BCAs and other aspects of the submission process.

3. Allow applicants and subapplicants to use other federally approved BCA tools (USACE) for grant applications

A) The benefits of permitting other federal BCA programs

FEMA should allow certain projects an option to use other federal BCA methodologies automatically. As a starting point, the BCAs used the United States Army Corps of Engineers (USACE) would allow FEMA subapplicants to process more datapoints and incorporate more benefits for some of their projects. This would enable subapplicants to develop larger and more complex projects, which is pursuant to FEMA's mitigation vision.

USACE uses the Hydrologic Engineering Center Flood Damage Reduction Analysis (HEC FDA) and Hydrologic Engineering Center Flood Impact Analysis (HEC FIA) as its BCA for hydrologic engineering studies. HEC FDA and HEC FIA may only apply to some FEMA analyses, but we argue that the benefits in these areas are strong enough for FEMA to accept HEC FDA or HEC FIA when it can apply. Perhaps most importantly, HEC FDA and HEC FIA do not seem to have the software issues that limit FEMA's BCA. It can import data, it presents tabulations reliably, and it does not malfunction randomly. The size of the data does not seem to affect HEC FDA or HEC FIA functionality.

In addition to USACE tools, BCAs used by the Environmental Protection Agency (EPA) and the Department of Housing and Urban Development (HUD) should be more widely considered acceptable. We suggest that FEMA collaborate with experts from these agencies to determine how these BCAs can apply to FEMA projects.[47]

B) The legal and practical basis for including other federal programs

We believe that USACE's BCA tools relevant federal BCAs for FEMA and should accepted for many of FEMA's hazard mitigation projects, which can be accomplished through a careful review of their applicability. Based on a review of Congressional legislation and Agency rulings related to the BCA, we anticipate no legal challenge for FEMA to permit the use of USACE's BCAs for certain projects.[48] USACE's BCA already pass federal muster, suggesting that an adoption by FEMA would not result in a legal challenge, at least at the Agency level. Existing

[47] Testimony from subapplicant, Region IV; Testimony from subapplicant, Region X.

[48] P.L. 93-288: Disaster Relief Act of 1974 (Robert T. Stafford Disaster Relief and Emergency Assistance Act) §404, §406; Title 44 CFR §1.4; OMB Circular A-94, revised.

litigation related to federal BCAs also suggests that this action would not face serious legal challenge in the Courts.[49]

The online portal FEMA Grants Outcomes (GO) provides subapplicants the option to submit a different BCA analysis with FEMA's permission. Obtaining FEMA's permission often becomes a complicated process, however, which contradicts the purpose of this white paper. Users must demonstrate that the FEMA's BCA cannot work for their project. Subapplicants have to apply to use a different BCA on a case-by-case basis.[50]

Instead, we argue that USACE's BCAs should be included as a formal extension of FEMA's option to submit a different BCA analysis in FEMA GO. Under this interpretation, FEMA can rule on the permanent inclusion of these BCAs for specified projects. For projects that are specified, applicants and subapplicants would be able to select an USACE BCA automatically. This would avoid exemption negotiations with FEMA that are often protracted, which is especially helpful for communities that lack the resources to pursue such a process.

Language in FEMA's most current Hazard Mitigation Assistance Guidance provides a basis for the automatic inclusion of other BCAs into FEMA's BCA process.
Section 1.11, "Alternative BCA Methodologies" states:

> Other methods to demonstrate cost-effectiveness may be used when they address a noncorrectable flaw in the FEMA-approved methodologies or propose a new approach that is unavailable using current tools. New methodologies may be used only if FEMA approves the methodology before application submission.[51]

As of this writing, USACE's tools offer a new approach to FEMA subapplicants that would be an enhancement to available tools. A reading of the term "noncorrectable" applies to the BCA users, since the problems in this paper cannot be corrected by users. This statement does not compel FEMA to review the applicability of a different BCA for every project, leaving open the possibility that the Agency could authorize another BCA for class of projects.

We recommend that FEMA consider USACE's BCAs first, but also suggest that FEMA consider EPA's and HUD's BCAs for other projects. We recommend that FEMA establishes a working group of FEMA policymakers, BCA experts, and BCA users to identify for which FEMA projects other BCAs could apply automatically. We want to strongly emphasize this recommendation, believing that this change could dramatically improve hazard mitigation by allowing communities to better leverage their already existing resources (including knowledge and expertise regarding other BCA tools).

[49] Caroline Cecot, W. Kip Viscusi, "Judicial Review of Agency Benefit-Cost Analysis," *George Mason Law Review* 22, no. 3 (Spring 2015): 575-618; *Thomas v. Peterson*, 753 F.2d 754 (9th Cir. 1985); *Entergy Corp. v. Riverkeeper, Inc.*, 556 U.S. 208, 129 S. Ct. 1498, 173 L. Ed. 2d 369 (2009).
[50] Testimony from subapplicant, Region IV.
[51] FEMA, *Hazard Mitigation Assistance Guidance: Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program* (2015), 68.

Longer-term Solutions

4. Fix the BCA software

This solution could resolve the technical issues to the BCA directly. Based on the analysis raised in the previous section, we recommend that this solution address at least three elements as effectively as possible:

- Include an import option for all data columns and do not limit the number of entries per column. The current import option needs to be expanded in both ways. The current import tool should be able to import thousands of datapoints simultaneously.
- Provide more clarity on how the BCR is tabulated in the software application and ensure that these tabulations remain consistent, especially for large projects. If implemented optimally, users should have the option to see how the BCA software calculates data in real time. Although no software is perfect, users should not be subjected to frequent, random crashes.
- Ensure that other bugs, which cause irregularities in BCR calculations or result in software crashes, are eliminated or reduced to the minimum extent possible. The software should be able to manage tens of thousands of datapoints simultaneously.

When considering this option, some users urge FEMA to consider delivering BCA versions like a software update that is standard to most tech companies. In the latter case, users can update their software without experiencing major disruption to their data or progress. A BCA software update, by contrast, is delivered in the form of a new version that supplants the previous version. There is no data transfer between versions. Based on standard operating procedures, users must restart projects from the beginning, since current FEMA guidelines dictate that applications must use the current software, irrespective whether the application was started before the release of the latest version.[52] Alternatively, FEMA could change its current ruling to grandfather projects that began with an older software for that project. It is important to note that users strongly recommended this feature but felt that it was less crucial than the three software updates listed above (A-C).

It is important to note that FEMA has also determined that a software-type update for new BCA versions would be beneficial. FEMA has noted that the current platform does allow for automatic updates and that Version 6.0 has, in fact, already been updated numerous times since its release in July 2019. The current platform also allows for an easy transition to a web-based platform.

5. Alter FEMA policy on data inputs and backup documentation

This solution seeks to address the input and documentation issues addressed in the policy section. Although we recognize the need for precision and backup documentation, streamlining the following solutions will prevent some of the policy issues addressed:

- Clearly outline a process and procedure if two acceptable sources of information generate different results.
- Reduce required documentation for some secondary benefits (e.g. the number of volunteers). Rather, allow the subapplicant to submit a qualitative narrative, especially when the secondary benefit has little impact on the BCR.

[52] Testimony from subapplicant, Region IV.

- Clearly define which documentation is acceptable for a certain input (this may involve the process of documentation, if necessary). Although FEMA defines documentation for some inputs, the guidance is inconsistent.
- Increase the range of acceptable benefits to include more benefits for less populated areas.
- Increase the range of projects that can be eligible for precalculated benefits
    a. Prioritize projects that clearly demonstrate high levels of avoided loss. For example, severe repetitive loss projects should automatically be cost effective. Similarly, various post flood mitigation actions should be automatically cost effective (e.g., upsizing culverts, acquiring flooded structures).
    b. Allow for some benefits to be added to precalculated benefits.
    c. Increase the financial limit for projects to avoid penalizing areas with high property values (higher cost of acquisition) or areas with renters (higher cost of relocation).

Similar to the BCA collaboration in 2008, we feel that FEMA can develop these solutions by collaborating with state, local, private, and academic partners.

6. Create a review program to accept additional FEMA-approved BCAs

There is some precedent for using independently designed benefit-cost analyses, at least post facto. In 2007, Rose et. al developed a BCA tool that retroactively conducted a BCA for 5,500 hazard mitigation projects, which suggests the possibly to create a BCA tool that can handle projects at scale but could conduct robust sensitivity analyses.[53] More recently, Taghinezhad et. al developed models to predict flood elevations for buildings across Louisiana and ran a Monte Carlo analysis to predict flood damages. As of this writing, several ongoing projects at Louisiana State University have expanded these concepts to wind and will continue to expand them to other hazards.[54] None of these studies attempted to prove that another BCA would supplant FEMA's current BCA. Nonetheless, results from both studies suggest the possibility that alternative BCAs could be used for many, if not most scenarios that the current BCA seeks to address.

Given the existence of BCA review tools are methodologically sophisticated, reliable, and accurate, even when processing big data, we encourage FEMA to consider building a review mechanism to authorize external BCAs for mitigation funding. In addition to improved functionality, offering a range of BCA mechanisms would allow subapplicants to incorporate new concerns that may be pertinent to their community or communities across the country.[55] Expanding Justice Brandeis's conception to mitigation, subapplicants could become

[53] Adam Rose, Keith Porter, Nicole Dash, Jawhar Bouabid, Charles Huyck, John Whitehead, Douglass Shaw et al. "Benefit-cost analysis of FEMA hazard mitigation grants," *Natural hazards review* 8, no. 4 (2007): 97-111.
[54] Arash Taghinezhad, Carol J. Friedland, and Robert V. Rohli, "Benefit-cost analysis of flood-mitigated residential buildings in Louisiana," *Housing and Society* (2020): 1-18; Arash Taghinezhad, "Virtual Interview," Louisiana State University, January 22, 2021.
[55] For examples of petitions to include other factors into the BCA, see: Craig P. Aubuchon and Kevin M. Morley, "The economic value of water: providing confidence and context to FEMA's methodology," *Journal of Homeland Security and Emergency Management* 10, no. 1 (2013): 245-265; Jia Li, Michael Mullan, and Jennifer Helgeson, "Improving the practice of economic analysis of climate change adaptation," *Journal of Benefit-Cost Analysis* 5, no. 3 (2014): 445-467.

"laboratories of mitigation," where more responsibility to develop ideas and best practices for benefits and costs would be allocated to FEMA's partners.

Similar to the third solution, there seems to be no legal basis that would preclude FEMA from approving more than one BCA analysis, provided that the BCA met the parameters of Congressional legislation and other relevant binding documents. FEMA has extensive experience establishing and executing review processes that meet federal guidelines. Establishing appropriate criteria for a BCA review may take some time because of its novelty, but we are confident that FEMA staff have the experience and resources to build an effective review mechanism. Including such a review mechanism may be FEMA's best option to enhance its BCA program pursuant to its vision.

Conclusion

BCA plays in important role in mitigation, however, the issues highlighted in this paper drastically limit its utility. We seek to reform the BCA so it can integrate into more the holistic model that FEMA encourages in other aspects of its mitigation grant process. We encourage improved consistency among FEMA Regions to aid in reaching this holistic model.

Reform of the BCA is long overdue. We appreciate FEMA's vision to continue to encourage communities to form new partnerships, develop innovative approaches, and consider threats more holistically. FEMA's approval of natural-systems solutions is just one example. We remain concerned, however, that the current BCA does not meet OMB directives, will continue to hinder mitigation efforts, and will prevent some communities from applying for mitigation funding altogether.

We hope that FEMA will consider the six recommended actions we have proposed in this paper:

Shorter-term

- Make software training more available.
- Increase the maximum funding available for project scoping.
- Allow applicants and subapplicants to use other federally approved BCA tools (USACE; consider EPA and HUD) for grant applications.

Longer-term

- Fix the BCA software.
- Alter FEMA policy on data inputs and backup documentation.
- Create a review program to accept additional FEMA-approved BCAs.

There are several avenues that FEMA could use to begin resolving some of these issues, which are outlined in the recommended actions section. Put concisely, we recommend that:

1) FEMA conducts internal reviews of these issues
2) FEMA establishes working groups of users, experts, policymakers and experts to address these issues
3) FEMA identifies the resources needed to resolve these problems and allocates the resources to do so

Although these three objects may be weighted differently for each recommended action, FEMA will benefit from some combination of them. The NHMA can help FEMA with this process, based on FEMA's needs and requests for assistance. At the very least, we expect this paper to

begin a formal dialogue with FEMA about reforming the BCA, similar to the dialogue that led to the 2008 BCA conference.

Appendix

The Natural Hazard Mitigation Association is grateful to the number of individuals and BCA users who offered their opinions and shared their experiences.

In memory of Mr. Tracy DePew, Cow Creek Band of the Umpqua Tribe of Indians. For pushing this issue at the national level through his work on the FEMA Hazard Mitigation Assistance External Stakeholder Working Group. He convincingly articulated his concerns with the BCA and how it fails to value natural resources for tribes equitably. His legacy lives on, and we will continue to seek equitable solutions for all in his memory.